International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
www.chemijournal.com
IJCS 2020; 8(6): 2239-2243

Received: 21-09-2020
Accepted: 24-10-2020

Nakambam Manoranjan Singh
Krishi Vigyan Kendra, Dima Hasao, Assam, India

Anil Kumar Tripathi
ICAR- Agricultural Technology Application Research Institute, Guwahati, India

Rashmita Saikia
Krishi Vigyan Kendra, Dima Hasao, Assam, India

Kabin Medhi
Krishi Vigyan Kendra, Dima Hasao, Assam, India

Shankar Hemanta Gogoi
Krishi Vigyan Kendra, Dima Hasao, Assam, India

Parkey Gogoi
Krishi Vigyan Kendra, Dima Hasao, Assam, India

Jiljily Thaosen
Krishi Vigyan Kendra, Dima Hasao, Assam, India

Sonia Langthasa
Krishi Vigyan Kendra, Dima Hasao, Assam, India

Dipak Kumar Mandal
Krishi Vigyan Kendra, Dima Hasao, Assam, India

Nehail Hojai
Krishi Vigyan Kendra, Dima Hasao, Assam, India

Corresponding Author:
Nakambam Manoranjan Singh
Krishi Vigyan Kendra, Dima Hasao, Assam, India

Effect of area specific mineral mixture supplementation on milk yield and reproductive traits of crossbred dairy cattle under sub-tropical region of north eastern India

Nakambam Manoranjan Singh, Anil Kumar Tripathi, Rashmita Saikia, Kabin Medhi, Shankar Hemanta Gogoi, Parkey Gogoi, Jiljily Thaosen, Sonia Langthasa, Dipak Kumar Mandal and Nehail Hojai

DOI: https://doi.org/10.22271/chemi.2020.v8.i6af.11108

Abstract
Nutrients requirement plays a very crucial role in regulating biological systems, immunological, health, lactation and reproductive performance in dairy cattle.Therefore, the present study was conducted to assess the effect of area specific mineral mixture supplementation on milk yield, reproductive performance and economic of dairy cattle for a period of 120 days. Experimental animals were selected randomly from four villages of Dima Hasao district of Assam. Twenty lactating crossbred cattle (n=20) were divided into two groups (10 milch cows/group) *viz*., treatment (T_2-supplement of 50gm mineral mixture/cattle/day) and control (T_1-no supplementation) in a completely randomized designed. Results revealed significant ($P<0.05$) improvement in milk yield by 1.36 litre per day (18.68%), reproductive performance and benefit cost ratio (3.55 vs 3.11) in the studied. Thus, mineral mixture supplementation in the diet of dairy cattle gave better results in improving milk yield and reproductive efficiency for sustainability livelihood in smallholders' dairy farming in hilly regions.

Keywords: milk yield, reproductive performance, area specific mineral mixture, dima hasao

1. Introduction
India has been the world's largest milk producer for the last two decades, with a 22.67 percent share of global dairy production. Around 70 million Indian households are projected to be active in dairy production vis-à-vis 150 million households worldwide (FAO, 2020) [1]. The dairy sector is a major subsidiary occupation and source of income for 75 percent of the Indian population, of which 30 percent are poor, living in rural areas (Douphrate *et al.*, 2013) [2]. In many livestock production systems, approximately two-thirds of improvements in livestock productivity can be attributed to improved nutrition (Fitzhugh, 1978) [3]. At present, the country is facing a net deficit of 35.6% green fodder, 10.95% dry crop residues and 44% concentrate feed ingredients to meet requirement of the growing livestock population (Dhawal *et al.*, 2020) [4]. Ca, P, Na, Co, Cu, I and Zn are the minerals most likely to be deficient under grazing conditions (McDowell, 1993) [5]. However, in all types of dairy animals, the effects of mineral deficiency and metabolic disorders have been observed due to lower mineral and vitamins content, available energy, protein, and poor bioavailability of essential macro and micro minerals from different feed staffs (Bhanderi *et al.*, 2014; Ramachandra *et et.*, 2007; Sharma *et al.*, 2005) [6, 7, 8]. In order to compensate for the low productivity of the animals, farmers fed only the productive animals optimally, and the rest of the animals (male, calves, spent female) are fed lower quantities or imbalanced diet. Nowadays, mineral nutrients play a key player role in controlling biological systems, development, health, lactation and reproduction, and microbial fermentation is well known in the animal rumen (Weiss, 2012; McDowell, 2003) [9, 10]. In rural areas or hilly regions, dairy cattle are largely dependent on grazing and crop residue with little or no additional concentrate or mineral mixture except common salt (Garg *et al.*, 2005) [11]. In the North Eastern Region (NER) of India, the total milk production in the region was 1454.17 thousand tones (17.60 percent) vis-à-vis the country's

187749.46 thousand tones (41.77 percent) (BAHS, 2019) [12]. Despite the socio-economic value of NER, under the smallholder dairy farming system, milk production is seasonally sensitive, with feed variations in both quantity and quality being the main driver. Due to feed scarcity, a dry season decrease in milk production of over 40 percent is a typical phenomenon. The adoption of improved technologies and practices for feed production, conservation and utilization in dairy farming communities is weak. Dairy productivity is constrained by farmers such as poor quality feed, shortage of feed resources, high cost of raw feed ingredients (65-70%), shortage of skilled and committed labour (28-32.5%), transportation charge were found to be major bottlenecks in these regions. In lactating dairy animal, insufficient supply of nutrient requirements led to a decline in milk yield, severe and prolonged energy and protein deficiency depresses reproductive function (NRC, 2001) [13]. Pressure on land and fodder resources and diminishing grazing land coupled with poor quality feed resources are one of the major challenges in dairy farming, especially widespread macro-and micro-mineral deficiency (Singh *et al.*, 2014; Kumaresan *et al.*, 2010) [14, 15]. The mineral concentration in crops and forages depends on the genus, species, variety, form of soil, environment and stage of maturity of the fodder (Gowda *et al.*, 2001) [16]. Mineral deficiencies or soil or forage imbalances have long been held responsible for low production and poor reproductive performance in tropical and subtropical agro-climatic conditions among cattle and buffaloes fed on crop residues (Garg *et al.*, 2008; Ghosh *et al.*, 2008; Das, 2003) [17, 18, 19]. With reference to area specific mineral mixture supplements in dairy cattle of these regions, literature is deficient or scanty. Increase in milk yield and reproductive efficiency as a result of area-specific mineral mixture supplementation recorded in some parts of India (Srivara, 2019; Meher *et al.*, 2017; Satapathy *et al.*, 2016) [20, 21, 22]. Therefore, the aim of the present study was envisaged to assess the effect of area specific mineral mixture supplement on milk yield and reproduction performance of dairy animals under agro-climatic condition of hilly region of Dima Hasao, Assam.

2. Materials and Methods

2.1 Study area

This experiment was carried out in lactating crossbred cattle under front line demonstrations at autonomous Dima Hasao district of Assam, India. Selection of four villages (Gadain Razi, Krishna Nagar, Upper Bagetar, and Lodi) by simple random sampling techniques was used for the study. This zone is located between $24^0$58 to 25.32^0N latitude and 92.27^0 to 93.43^0E longitudes with an altitude varying from 140 to 1868 meters above the mean sea level. The area experiences sub-tropical and humid climate zone with temperature varies from 6.02^0C to 14.7^0C during winter and 14.31^0C to 33.06^0C during summer and 1145mm of annual rainfall.

2.2 Animal, Experimental diet and management

All the animals were selected at a mid stage of 2nd lactation, milk yield and parity. A total of twenty lactating crossbred cattle (n=20) were divided into two groups (10 milch cows/group) *viz*., treatment and control. Animals from the treatment group (n=10) were fed area specific mineral mixture (AAUVETMIN) developed by Assam Agricultural University at the rate of 50 gram/cattle/day, whereas cattle from the control group were not given any supplementation. Composition of area Specific Mineral Mixture ((AAUVETMIN) contain calcium (17.60), Phosphorus (7.00), Magnesium (1.50), Zinc (0.13) and copper (0.08) respectively, measured in percentage by mass. Feeding practices by farmers were similar in both the group except the supplementation of AAUVETMIN in the treatment group only. Standard animal management practices were followed in the farmer's field. Animals were fed green fodder, hay and concentrate feed as per specific recommendation of standard feeding ration schedule (ICAR, 2013) [23]. Water was offered ad libitum throughout the experimental period. The feeding trial was lasted for 120 days.

2.3 Data collection on milk yield, reproductive performance and cost benefit ratio

Milk yield was recorded daily, twice both in morning and evening at 6:00 and 17:00 hours by the farmers and at weekly interval by the researcher. Data on reproductive traits *viz*. post-partum estrus, service period and number of artificial insemination required for conception were recorded on the basis of dairy cow owner's response. The benefit cost ratio for all the groups were calculated. A training programme was conducted for the farmers before starting the experiment to educate them for feeding and correct method of data recording on different parameters in the adopted villages.

2.4 Statistical Analysis

The data were analyzed statistically as per Snedecor and Cochran, 1989 [24] and student's t-test of significance (2 way split analysis of variance) between groups were performed using SPSS for Windows (version 17.0 Microsoft).

3. Results and discussion

3.1 Effects on Milk yield

The experiments were performed with dietary supplementation area specific mineral mixture to find out whether AAUVETMIN will have any effect or any change on milk yield, reproductive performance and benefit cost ratio in crossbred dairy cattle in this hilly region. The observations on milk production, reproductive traits and economic impact on dairy cattle are presented in Table-1. The average milk yield in treated group was found significantly higher (p<0.05) as

Table 1: Effect of area specific mineral mixture supplementation in milk yield in dairy cattle

Parameter (a) Milk yield (litre/day)	Control group(T_2) (n=10)	Treatment group(T_2) (n=10)	SEM	t-value	Level of significance
1. Initial (0 day)	7.16[a]	7.28[a]	1.08	1.78	NS
2. Final average (30-120 days)	7.28[a]	8.64[b]	0.14	1.25	*
3. Change in milk production (%)	-	18.68	-	-	-
4. Average milk Fat%	4.74	4.78	0.21	3.67	NS
5. Average milk SNF%	8.88	8.92	0.11	2.03	NS

Numbers of observations are given in parentheses. Means bearing the different superscript within a row differ statistically significant; * P<0.05, NS-Non significant

compared to its yield observed in control group. These finding were in agreement with the results reported by Srivara (2019) [20]; Meher *et al.* (2017) [21] and Gupta *et al.* (2017) [25] in crossbred cattle. Pandey *et al.* (2018) [26] and Nocek *et al.* (2006) [27] also reported increase in milk yield due to supplementation of area specific mineral mixture in dairy cattle. Mohsina *et al.* (2017) [28] and Tiwari *et al.* (2013) [29] reported feeding of area specific mineral mixture increased milk yield 25% in field trials. Similar to the present findings, Hackbart *et al.* (2010) [30] observed increase in milk production at 14 week supplementation of organic trace minerals to cattle. This finding was in line with Akila *et al.* (2013) [31] and Senthilkumar *et al.* (2015) [32] who were reported that supplementation of TANUVAS – mineral mixture to a dairy cattle resulted in increase in milk yield by 1.46± 0.14 and one litre per day in cow respectively. Singh *et al.* (2016) [33] observed significantly higher (p<0.05) milk production in supplemented animal with mineral mixture. However, result indicating that dietary mineral mixture supplementation attributes improved milk production potential of cattle could be due to having impact on the mammary myoepithials cells-smooth muscle alpha-actin (ACTA2) in the udder during lactation. Further, synergistic effect of micro and micro elements contribute in the working of memory cells to enhance their productivity. This finding was in accordance with Ghosh *et al.* (2016) [34] and Rohilla *et al.* (2007) [35] observation. The present results support the findings of Rabiee *et al.* (2010) [36] and Mohsina *et al.* (2017) [28] observed no significant differences in milk fat % and milk SNF % between the supplemented and non-supplemented groups of animals.

3.2. Effects on reproductive performance

Reproductive traits i.e. onset of first Post-partum estrus after calving, service period and number of insemination per conception were also recorded during the experimental period as shown in Table- 2. These reproductive traits significantly (P≤0.05) differed in the treatment group of dairy animals as compared to control group. The supplemented group of animals voluntary waiting period (48.37 days) was observed slightly lower than the control group (63.21 days). On average onset of first postpartum estrus was observed to occur 14.84 days earlier in the supplement animals as compared to control group. Moreover, the mineral mixture fed group with a service period (62.37 days) was also found significantly (P≤0.05) lower than the control group (86.21 days). Similar findings were also reported by Sivara (2019) [20], Gupta *et al.* (2017) [25], Sahoo *et al.* (2017) [37], Mohapatra *et al.* (2012) [38] and Devasenat *et al.* (2010) [39] in crossbred cattle. Significant effect of service period and number of insemination required for conception was evident from the present study. The present results support the findings of Selvaraju *et al.* (2009) [40] regarding improvement in general health score condition of the cows after area specific mineral mixture supplementation. The improvement in reproductive efficiency in cattle could be attributed due to mineral supplementation as compared to the performance of non-supplemented group was very clear in this study.

Table 2: Effect of area specific mineral mixture supplementation in reproductive performance

Parameter (a) Reproductive Traits	Control group(T_1) (n=10)	Treatment group(T_2) (n=10)	SEM	t-value	Level of significance
1.Onset of first post-partum estrus (days) after calving	63.21[a]	48.37[b]	6.83	24.16	*
2. Service period (days)	86.21[a]	62.37[b]	7.89	28.74	*
3. Number of insemination/conception	3.82[a]	1.73[b]	0.65	5.82	**

Numbers of observations are given in parentheses. Means bearing the different superscript within a row differ statistically significant; * P<0.05; **P<0.01, NS-Non significant

3.3. Cost of milk production and Benefit Cost ratio (BCR)

The economic analysis of the data revealed that dietary supplementation of area specific mineral mixture enhances the milk yield by 18.68 % per day in treated group. It could be inferred from Table-3 that benefit cost ratio was higher (p<0.05) in supplement animals as compared to control group. The feeding cost of per litre of milk was lower (₹ 22.73) in treatment group as compared to control group (₹ 25.80). Gross return from sale of milk (₹ 691.20 vs 582.40) and net profit litre of milk was found to be higher in treatment group (₹ 57.34) than control group (₹ 54.31). The BCR was also found higher in treatment group as compared to control (₹ 3.55 vs 3.11). Similar result to the present finding was in accordance with Sivara (2019) [20] in milch cattle.

Table 3: Economics impact of area specific mineral mixture supplementation benefit cost ratio in dairy cattle

Parameter (a) Milk yield (litre/day)	Control group(T_1) (n=10)	Treatment group(T_2) (n=10)	SEM	t-value	Level of significance
1. Initial (0 day)	7.16[a]	7.28[a]	1.08	1.78	NS
2. Final average (30-120 days)	7.28[a]	8.64[b]	0.14	1.25	*
(b) Benefit cost ratio					
1. Cost of feeding /day/cow[†] (₹)	187.00[a]	194.50[b]	0.52	4.78	*
2. Average feed cost per litre of milk production (₹)	25.68[a]	22.51[b]	6.62	24.23	*
3. Gross return from sale of milk (₹80/Litre)	582.40[a]	691.20[b]	3.57	12.66	*
4. Net profit per day (₹)	395.40[a]	496.70[b]	2.68	11.46	*
5. Net profit per litre of milk (₹)	54.31[a]	57.48[b]	7.63	36.83	*
6. Benefit: Cost ratio	3.11[a]	3.55[b]	0.61	5.62	**

Numbers of observations are given in parentheses. Means bearing the different superscript within a row differ statistically significant; * P<0.05; **P<0.01; [†]price is varies in hilly region, NS-Non significant

4. Conclusions

It can be concluded from the present study that dietary supplementation of mineral mixture to the lactating crossbred

dairy cattle under field conditions not only increases the milk yield, but also reduce cost per litre of milk production and reproductive efficiency and consequently improving socio-economic conditions and can earn more profit from their milch cattle by smallholders' dairy farmer in hilly region.

5. Conflict of interest

Authors declare that there is no conflict of interests arising from this study.

6. Acknowledgments

The authors extend their sincere thanks to the Chief trustee, Keshav Smarak Nyas and Director, ICAR- Agricultural Technology Application Research Institute (ATARI), Zone VI, Guwahati-781006, India for providing financial funds and necessary infrastructure support to conduct the research work in the farmer's field.

8. References

1. FAO. Dairy Market Review-Emerging trends and outlook, December 2020. http://www. fao. org /3/cb2322en/CB2322EN.pdf
2. Douphrate ID, Robert H, Mathew N, Chrishina LK, Martina J *et al*. The Dairy Industry: A Brief Description of Production Practices, Trends, and Farm Characteristics Around the World 2013, Journal of Agromedicine 2013;18:187-197. DOI: 10.1080/1059924X.2013.796901
3. Fitzhugh. Animal size and efficiency, with special reference to the breeding female. Animal Science 1978;27:393-401.
4. Dhawal Kant Yadav, Panch Kishor Bharti, Amit Kumar Singh, Manmohan Singh Rajpoot, Gyanendra Kumar Gaur *et al*. Palatability assessment of treated feed with certain ingredients in crossbred dairy cattle under sub-tropical conditions, International Journal of Chemical Studies 2020;8(1):1776-1780. DOI: https://doi.org/10.22271/chemi.2020.v8.i1z.8522
5. McDowell LR, Conrad JH, Hembry FG. Minerals for grazing ruminants in tropical regions. University of Florida, Gainesville 1993.
6. Bhannderi BM, Garg MR, Sherasia PL. Mineral Status of Feeds, Fodders and Dairy Animals in Jalgaon District of Maharastra State, Sch. J Agric. Vet Sci 2014;1(4A):222-226.
7. Ramachandra KS, Taneja VK, Sampath KT, Anandan S, Angadi UB. Livestock Feed Resources in Different Agro-ecosystems of India: Availability, Requirement and their Management. National Institute of Animal Nutrition and Physiology, Bangalore 2007.
8. Sharma MC, Joshi C, Kumar M. Micro Mineral Deficiency Disorders and Treatment: A Review. Ind J Anim Sci 2005;75(2):246-257.
9. Weiss WP. Minerals and Vitamins for Dairy Cows: Magic Bullets or Just Bullets? USA: Department of Animal Science, Cornell University 2012.
10. McDowell LR. Minerals in Animal and Human Nutrition. 2nd Edn. Amsterdam, the Netherlands: Elsevier Science 2003.
11. Garg MR, Bhanderi BM, Sherasia PL. Assessment of adequacy of macro and micro mineral content of feedstuffs for dairy animals in semi-arid zone of Rajasthan. Anim. Nutr. Feed Tech 2005;5:9-20.
12. Basic Animal Husbandry Statistics. Ministry of Fisheries, Animal Husbandry and dairying, Department of Animal Husbandry and Dairying, Krishi Bhawan, New Delhi 2019.
13. NRC. Nutrient Requirements of Dairy Cattle. 7th rev. ed. National Academy Press, Washington, DC 2001, 408.
14. Singh S, Mishra AK, Singh JB, Rai SK, Baig MJ, Biradar N *et al*. Water requirement estimates of feed and fodder production for Indian livestock vis a vis livestock water productivity. Indian J Anim Sci 2014;10(84):1090-1094.
15. Kumarasen A, Bujarbaruah KK, Pathak KA, Bhajendra, Ramesh T. Soil-plant-animal continuum in relation to macro and micro mineral status of dairy cattle in subtropical hill agro ecosystem. Trop Anim Health Prod 2010;42:569-577.
16. Gowda NKS, Prasad CS, Ramana JV, Ramachandra KS. Micronutrient content of soil, feeds, fodders and blood samples of animals in southern dry and eastern dry zones of Karnataka. Indian Journal of Animal Sciences 2001;71:150-154.
17. Garg MR, Bhanderi BM, Kumar SS, Sherasia PL. Macro and micro minerals status of dairy animals in hilly zone of kerala. Anim. Nutr. Feed Tech 2008;8:13-23.
18. Ghosh MK, Konwar P, Basumatary R *et al*. Mineral Profile of Local Tree Fodders and Grasses of Maghalaya. Ind Vet J 2008;85:105-106.
19. Das A, Ghosh TK, Haldar S. Mineral distribution in soil, feeds and grazing cattle of different physiological stages in the red laterite and new alluvial agro climatic zones of West Bengal. Indian Journal of Animal Sciences 2003;73:448-454.
20. Srivara Bhuvaneswari B. Assessment of area specific mineral mixture supplementation. International Journal of Research and Analytical Reviews 2019;6(2):546-549.
21. Meher P, Mishra SK, Sethy K, Swain RK, Sahoo G, Meher S. Nutrient availability and supplementation of area specific mineral s and vitamins on the performance of crossbred cows in Bargarh district of Odisha. Exploratory Animal and Medical Research 2017;7:48-52.
22. Satapathy D, Mishra SK, Swain RK, Sethy K, Sahoo GR. Effect of Supplementation of Area Specific Mineral Mixture on Performance of Crossbred Cows with Reproductive Disorders in Kakatpur Block. Indian Journal of Animal Nutrition 2016;33:279-284.
23. ICAR. Nutrient requirements of cattle and Buffaloes. Indian Council of Agricultural Research, New Delhi 2013.
24. Snedecor GW, Cochran WG. Statistical Methods, 1st East-West Press ed. Affiliated East West Private Ltd. New Delhi 1994.
25. Gupta R, Singh K, Sharma M, Kumar M. Effect of Supplementation of Minerals on the Productive and Reproductive Performance of Crossbred Cattle. International Journal of Livestock Research 2017;7(12):231-236 http://dx.doi.org/10.5455/ijlr 20170717113236.
26. Pandey VK, Gendley MK, Tiwari SP, Prusty S. Effect of area specific mineral mixture on serum biochemical parameters and milk yield in dairy cattle 2018;10(1):4965-4968.
27. Nocek JE, Socha MT, Tomlinson DJ. The effect of trace mineral fortification level and source on performance of dairy cattle. Journal of Dairy Science 2006;89:2679-2693.
28. Mohsina Mushtaq, Randhawa SNS, Randhawa CS, Gupta DK. Effect of Area Specific Mineral Mixture Supplementation on Milk Yield and Milk Quality in

Dairy Animals of Sub – Mountainous Zone of Punjap. J. Anim. Rsh 2017;7(4):763-67.
29. Tiwari R, Sharma MC, Singh BP. Indian J. Anim Sci 2013;83(4):435-437.
30. Hackbart KS, Ferreira RM, Dietsche AA, Socha T, Shaver RD, Wiltbank MC *et al*. Effect of dietry organic Zinc, Manganese, Copper and Cobalt supplementation on milk production, follicular growth, embryo quality and tissue mineral concentrations in dairy cows. J Anim. Sci 2010;88(12):3856-70.
31. Akila N, Senthilvel K. Impact of TANUVAS Cattle mineral mixture in productive and reproductive performance of dairy animals. Indian Cow 2013;10:31-35.
32. Senthilkumar S, Prathaban S, Thanaseelaan V, Manivannan C. Impact assessment of TANUVAS – mineral mixture on the productive performance of dairy cattle. Indian J Anim. Res 2016;50(5):824-825.
33. Singh S, Chhabra S, Singh C, Randhawa SS, Gupta DK. Effect of Area Specific Mineral Mixture Feeding on Milk Yield and Composition of Dairy Animals of Central Zone of Punjab, International Journal of Livestock Research 2016;6(3):62-65.
34. Ghosh MK, Mondal M, Rakesh Kumar Verma *et al*. Use of area specific mineral mixture to ameliorate region specific reproductive problems in ruminants. Research & Reviews: Journal of Dairy Science and Technology 2016;5(1):1-4.
35. Rohilla PP, Bohra HC. Effect of Nutrimix Feeding on Milk Yield of Ewe and Growth of Lambs, Indian Vet J 2007;84:1273-1275.
36. Rabiee AR, Lean IJ, Stevenson MA, Socha MT. Effects of feeding organic trace minerals on milk production and reproductive performance in lactating dairy cows: A meta analysis J Dairy Sci 2010;93:4239-51.
37. Sahoo B, Kumar R, Garg AK, Mohanta RK, Agarwal A, Sharma AK. Effect of Supplementing Area Specific Mineral Mixture on Productive Performance of Crossbred Cows. Indian Journal of Animal Nutrition 2017;34(4):414-419.
38. Mohapatra P, Swain RK, Mishra SK, Sahoo G, Rout KK. Effect of supplementation of area specific mineral mixture on reproductive performance of the cows. Indian J Anim. Sci 2012;82:1558-1563.
39. Devasenat B, Reddy IJ, Ramana JV, Prasad P, Eswara, Prasad J. Rama. Effect of Supplementation of Area Specific Mineral Mixture on Reproductive Performance of Crossbred Cattle -A Field Study. Indian J Anim. Nutrition 2010;27(3):265-270.
40. Selvaraju S, Reddy IJ, Gowda NKS *et al*. Effect of Supplementation of Area Specific Mineral Mixture in Improving Reproductive Efficiency in Crossbred Dairy Cattle-A Field Study. Ind J Anim Sci 2009, 79(6).